BAM2016

This paper is from the BAM2016 Conference Proceedings

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DETERMINANTS OF ECO-INNOVATIONS IN BRAZILIAN FIRMS: A REVIEW

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Summary: For many years, the imperatives of innovation have been oriented to competiveness achievement, not to environmental concerns. The debates about the role of governments, business, citizens and the diversity of global and social actors in seeking answers to short and long term environmental problems, especially related to greenhouse gases emissions have increased. This paper provides an overview of the recent body of literature in the field of eco-innovations in Brazil, identifying determinants and impacts of the adoption by the firms. It also contributes to the discussion of the relationship between Brazilian policies and regulations and the implementation of eco-innovations by Brazilian firms. The study analysed data from empirical studies in three databases: Scopus, Web of Science and SciELO. Although ecological issues became part of the innovation agenda and eco-innovation is already a crucial field, Brazil lacks specific literature on the area and needs to advance a local discussion. With a tradition of having a very bureaucratic public administration which is sensitive to political interference, the innovation policies did not deal with environmental issues until very recently. Environmental and innovation policies should be aligned, complementing each other.

Track 9: Innovation

Total number of words: 5,869

1. Introduction

Climate change and other environmental threads increase the hope that innovations, sooner or later, will solve our ecological problems. Probably, not all ecological problems can be solved entirely via technological innovations. For Veiga and Issberner (2010), "the innovations, particularly the technological ones, are part of the solution. But they have also been part of the ecological problem", because for many years, the imperatives of innovation have been oriented to competiveness achievement, not to environmental concerns. The debates about the role of governments, business, citizens and the diversity of global and social actors in seeking answers to short and long term environmental problems, especially related to greenhouse gases emissions have increased. They can be found within different sectors and regions when discussing the challenges of sustainable development. Business which invests in technologies that address aspects from energy use to water conservation is now required from private sector (Bansal, 2005; Freeman et al., 2010; Zollo et al., 2013). In terms of environmental aspects, reduction of emissions, adoption of clean technologies, management of natural resources and waste and the investments in renewable energy sources require the adoption of innovations – be it in products, processes, and forms of management or service offering. Having an active position towards ecological issues became part of the global innovation agenda, since the "Green Economy Initiative" (GEI), launched in 2008 by the United Nations Environment Programme (UNEP). In the last decade, studies have shown that there is an increasing pressure for firms' adoption of regulations and technologies that minimize ecological damage (Delmas, 2003; Gunningham et al., 2003). Under this new perspective, it would allow them to, in some cases, reduce costs and to enter into new markets for ecological products and services. On the other hand, it generates an opportunity for a new market creation related to technologies which are more efficient in the use of raw material, new energy sources and so on (Porter and Linde, 1995; Elkington, 1997). In more recent years, firms have increased their commitment level towards environmental sustainability and more executives believe it positively contributes to their firms' short- and long-term value. (MIT, 2011; McKinsey, 2011). These issues require investigation on how organizations are able to deal with them and to examine their routines to change traditional behaviours.

There is a current special interest in understanding how the developing economies, such as BRICs, do so. Latin America has a leading role in the environmental innovation – or eco-innovation – scenario while it is also challenged by global economic players such as China and India (InnovaLatino, 2011). Despite the improvements in the conditions for the development of innovations, like economic stability and increase on human capital accumulation, there are still many difficulties to the development and adoption of eco-innovations in South America. Among them, Rozenwurce et al. (2008) mention: focus on technology adoption rather than innovation; scant public R&D institutional and business links; modest public policy relevance; lower propensity of businesses to implement eco-innovative technologies; and public funds being increasingly channelled via ministries that are not directly responsible for environmental policies, thus making inter-departmental cooperation even more necessary.

Several of the South American countries have introduced new innovation-dedicated bodies in order to create a better environment for eco-innovation and to try to overcome some of these challenges. In Brazil, for example, among other institutions with activities

dedicated to support innovation development, there is FINEP, the Federal Innovation Financing Agency, which in recent years has created an innovation incubator and venture capital vehicles to promote innovation, among other actions. In spite of this governmental support, there is much to be discussed about the innovation policies in Brazil and how they encourage firms to implement eco-innovations. Tax exemption for cars production, held until the end of the year 2014, without any compensation in terms of ecological measures, are an example of the ambiguity of the Brazilian government commitment to sustainable development. It is also relevant to discuss if and why Brazilian companies are strengthening their commitment to environmental sustainability.

Zollo et al. (2013) argue that though the studies on sustainability brought important contributions on how to improve long-term economic performance, they generally do not approach the underlying model of the firm's role. The same happens to the studies on the impact of firm activities on the natural environment (Zollo et al., 2013). They pointed out institutional pressure and legitimization processes as common issues (King and Lenox, 2000; Sharma and Vredenburg, 1998) and highlight that firms tend to adopt environmental standards when there is institutional pressure and a need for legitimacy (Sharma and Vredenburg, 1998). Particularly in the Brazilian context, discussions on eco-innovation can be considered relatively new and do not yet form a set of systematic studies. There is an important gap in literature on the effectiveness of national policies in fostering the implementation of eco-innovations by firms (Bastos, 2012; Rocha, 2014). Generating information that helps the understanding of the process of creation, adoption and diffusion of eco-innovation is crucial for the development of public policies and private organization strategies.

This paper it aims at providing an overview of the existing body of literature in the field of eco-innovations in Brazil, focusing on empirical studies to identify some of the determinants and impacts of the adoption of eco-innovations by Brazilian firms. It aims at improving the theoretical understanding of the development and adoption of eco-innovations in firms and its relationship with the Brazilian policies.

The next section is dedicated to discuss the different notions used to describe innovations with a reduced negative environmental impact and the main determinants for the adoption of eco-innovations. The methodological approach is discussed in the third section. Fourth section presents the legal and regulatory framework in the Brazilian context. Fifth section presents findings from the search in the databases. Then, discussion and conclusions are presented in the last sections.

2. Theoretical Background

2.1. Discussing the concept of Eco-innovation

The concept of eco-innovation is relatively new. It emerges in a context in which the environment gains visibility in economic and political global discussions. Concerns about environmental impacts and the role played by innovation and technology are questioned. One of the first uses of the term in the specialized literature was done by Fussler and James (1996) in their book *Driving Eco-Innovation*, where they define eco-innovations as “new products and processes which provide customer and business value

but significantly decrease environmental impact". Along the same lines, most definitions which have been stated since then differ from the definition of innovation in Schumpeterian terms[1] in relation to the reduction of environmental burdens.

Some later definitions of eco-innovation added an approach from the industrial dynamics perspective. Andersen (2008) and Foxon and Andersen (2009), for example, define eco-innovation as an innovation that is able to attract the so called green rents in the market, reducing the net environmental impacts, while creating value for organizations. According to Ekins (2010), eco-innovation can be understood as a change that benefits the environment to some extent, but that can only be judged considering an increase on the economic and environmental performance.

For the purposes of this paper, we use a concept which is described in an EU funded research project called "Measuring Eco-Innovation" (MEI)[2]. Based on the Oslo Manual (2005)[3], Kemp and Pearson (2007) developed a definition for eco-innovation, proposed at this report:

> "the production, assimilation or exploitation of a product, production process, service or management or business method that is new to the organization (developing or adopting it) and which results, throughout its life cycle, in reductions in environmental risks, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives " (Kemp and Pearson, 2007, p. 7).

This definition adds environmental gains when compared to other technologies available for the same purpose (Kemp and Arundel, 1998; Rennings and Zwick, 2003; Kemp, 2009). However, Kemp and Pearson (2007) point out an important aspect in the concept of eco-innovations. It is not enough that a final technology, product or service have a satisfactory environmental performance. It is also necessary that the product life cycle and the supply chain are analysed, from the primary source of raw material to the final place of destination (Hellström, 2007; Jansson, 2011). It is not unusual that many products and services which are considered sustainable may have a production chain that ultimately invalidates the environmental benefits of its use (Kemp and Pearson, 2007; Kemp, 2009). The aspects related to the environmental outcomes and the novelty, for the firm or the market, are also considered essential to characterise an eco-innovation, which is consistent with the OECD adopted definition of innovation in general. (Kemp and Foxon, 2007; Belin *et al.*, 2009).

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[1] Schumpeter, J. A. (1934, 1980). The theory of economic development. Oxford University Press: London.

[2] MEI is a project for DG Research of the European Commission, carried out in collaboration with Eurostat, the European Environment Agency (EEA) and the Joint Research Centre (JRC) of the European Commission. It offers a conceptual clarification of eco-innovation (developing a typology) and discusses possible indicators, leading to proposals for eco-innovation measurement.

[3] The Oslo Manual (OECD 2005) defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practice" (where implementation means realization for use).

2.2. Determinants for the adoption of eco-innovations

Firms play an important role in the environmental context. Products and services are directly connected to people's lives and often influence their way of acting and consuming (Porter and Linde, 1995). Great part of the environmental impacts is generated by companies, which are considered the main agents of the environmental damages and the largest consumers of natural resources (Hart, 1997; Porter and Linde, 1995). For the firms, innovation is considered crucial for the generation of returns and the ability to innovate becomes an important competitive advantage. Among other factors, innovation increases the possibility of reducing production costs and improves the quality and performance of products or services. Studies on the environmental management literature show that the reasons for the adoption of eco-innovation may be related to competitive advantage achievement or to the market pressures (Young and Lustosa, 2001; Podcameni, 2007; Kamerer, 2009). Firms look for increased efficiency and cost savings and to reach new 'green' consumer markets (Bansal and Roth, 2000). Firms' ethical concerns and institutional pressures by external stakeholders seem to be some other reasons for the adoption of eco-innovations (González-Benito and González-Benito, 2005).

Bernauer *et al.* (2006) points three main determinants for the development and / or implementation of environmental innovations: regulatory pressure, market, and factors which are internal to the company. Horbach *et al*. (2012) add a forth element to this group of factors: technology. Other studies also indicate that among the main determinants for the adoption of eco-innovations factors we can find: environmental policies, technological capabilities accumulated by the company (in particular R&D), and consumer preference for environmental friendly products (Belin *et al.*, 2009).

Pereira and Vence (2012) analysed fourteen empirical studies at the firm level, between 2006-2011 and identified four categories of eco-innovation determinants: structural characteristics of the firm (size; sector; age); business logic (costs reduction; consumer needs, benefits and satisfaction; expectation of demand; export-oriented strategy); technological competency (R&D activities; path dependency; qualification of the employees; cooperation and networking; Relationships with other companies from the industry); environmental strategy of the company / Innovation Management and Marketing (environmental management systems; environmental criteria in product planning and development; company product life cycle evaluation activities; waste disposal and reverse logistics; environmental labelling; market research on green products; Information from consumers).

In Brazil, for example, legislation enacted in 2005 introduced new tax incentives for innovation in the production context aimed at training and reaching the technological autonomy and industrial development of the country. It was a part of a group of broader actions to decrease the tax burden on the business sector and to favour the sharing of proceeds from intellectual property rights between businesses, public universities and research institutions (EIO 2012). Nevertheless, there is still the need to mitigate the shortage of skills in the labour force, considered a relevant barrier to innovation in Brazil, particularly in tertiary educational attainment (OECD 2011). Some initiatives have been introduced to reduce barriers to the deployment of environmentally-friendly technologies. At the same time, there are legislations which can negatively affect the environment. However, these issues still need to be investigated. There are few studies

that propose to examine these factors and their impact, especially within the Brazilian companies, thus corroborating the need for more theoretical and empirical studies to be developed in this context.

Rennings (2000) highlights that innovation and environmental policies should be complementary and eco-innovation adoption could reduce the costs of social, institutional and technological innovation. Foxon and Andersen (2009) corroborate this idea and notice that innovation policies almost do not deal with environmental area until recently. At the same time, environment concerns have widely been understood as expensive by firms.

Innovation process and activities involve a high level of uncertainty (Freeman, 1989) and a complex system of market and hierarchical relations (Fagerberg et al. 2005), which many times cause underinvestment by firms. This may be a reason to justify governmental support to innovative activities (Rocha, 2014). Some studies argue governmental intervention on the technology environment has positive effects (Pelei 2006, Block 2008). In general, they understand state plays an entrepreneurial role in order to help firms to acquire knowledge and capabilities so they can develop innovative activities. Other studies tried to measure the effects of R&D subsidies (R&D grants, subvention, funding and tax incentives) in terms of innovativeness, firm or productivity growth, but the effects of governmental support was not very clear (Wallsten 2000; David, Hall and Toole 2000; Hall and Reenen 2000).

Pavitt (2005) discusses the pros and cons of governmental support and emphasizes the pressure groups and opportunity costs, on the one hand, and the commercial constraints and gains of early technological learning, on the other. Lerner (2010) questions the wide governmental intervention in innovative efforts as he argues there is risk of failure in giving resources to unqualified programs or institutions. Other agents can influence the decisions leading to waste of resources which demands caution (Lerner 2010).

3. Research Methodology

Methodologies for measuring eco-innovations usually are classified in four categories: input measures, intermediate output measures, direct output measures, and indirect impact measures (Kemp, 2009; OECD, 2009). As discussed by Kemp and Arundel (1998), each method has advantages and disadvantages and though some can be considered better than others, not a single measure can be considered ideal. This study analyses intermediate output measures using scientific publications[4] as its source for data collection[5].

Identifying the core contributions of a field is a usual methodology to review an emerging literature. Our study is organized as a literature review on the Brazilian context for eco-innovating: first, it analyses legal and regulatory framework related to environment and innovation; second, it searches for literature on eco-innovation in three

[4] For the purposes of this paper, academic publications from the databases were: paper from journals; reports; proceedings; reviews; and research developed by scientists.

[5] The other intermediate output identified is number of patents (Kemp, 2009; OECD, 2009) considered by Kemp (2009) the most used measure but at the same time a poor indicator for several reasons.

databases; and last, it reviews the empirical studies identified in the previous search. The analysis of the legal and regulatory framework tries to identify and explore the existing policies and regulations in Brazil related to the context of eco-innovation, environment and innovation in general. The literature review aims at examining the concepts and use of the term eco-innovation in the Brazilian context and the main thematic trends as well as identifying the empirical studies. The last step focuses on the empirical studies in order to examine how and why Brazilian companies implemented the eco-innovations identified. We want to observe the determinants for the adoption of eco-innovations, the impact of their use and the influence of the Brazilian policies.

For the legal and regulatory framework, the main sources of data collection were the websites of the Brazilian Ministry of Environment[6], Executive Office of the President (Casa Civil)[7] and Ministry of Science, Technology and Innovation[8]. Besides other attributions, these government departments offer repositories of laws and regulations where it is possible to find the legislation concerning environmental and innovation issues.

For the literature review, the data set was collected from three databases: Scopus, Web of Science and SciELO (Scientific Electronic Library Online). All the searches were made through "Portal de Periódicos CAPES"[9] as it gives free access to journals and databases for researchers from public universities. According to "Portal de Periódicos CAPES", **Web of Science** is a database of references with abstracts that indexes only the most cited journals in each area of knowledge. It offers more than 9,000 journals and 5 collections: Science Citation Index Expanded (SCI-EXPANDED) - since 1945; Social Sciences Citation Index (SSCI) - since 1956; Arts & Humanities Citation Index (A&HCI) – since 1975; Conference Proceedings Citation Index- Science (CPCI-S) - since 1991 and Conference Proceedings Citation Index - Social Science & Humanities (CPCI-SSH) - since 1991. **Scopus** is a database of references with abstracts. It offers more than 21,000 journals from 5,000 international editors and also indexes peer-reviewed academic titles, open access titles, conference proceedings, trade publications, book series, scientific content of web pages and patents. It offers features to support the results of analysis (bibliometrics) as identification of authors and affiliations, citation analysis, analysis of publications and *h*-index. It covers the areas of Life Sciences,

[6] The Ministry of Environment was created in November 1992. According to the presentation on the website "Its mission is to promote the adoption of principles and strategies for environmental knowledge, protection and restoration; sustainable use of natural resources; the valuation of environmental services and the inclusion of sustainable development in the formulation and implementation of public policies in a transverse, shared, participatory and democratic manner, at all levels and instances of government and society". http://www.mma.gov.br/

[7] According to Law No. 10683, May 28, 2003, the attributions of the Executive Office of the President are: "I) to watch directly and immediately to the President in the performance of his/her duties, particularly in the: a) coordination and integration of government actions; b) prior verification of constitutionality and legality of presidential acts; c) examination of the merits, appropriateness and compatibility of the proposals, including the matters in the National Congress, with government guidelines; d) evaluation and monitoring of government action and management of agencies and entities of the federal public administration; and II) to promote the publication and maintenance of official acts." http://www.casacivil.gov.br/

[8] http://www.mcti.gov.br/

[9] CAPES is the Higher Education Personnel Training Coordination. The Journals Portal is a virtual library that collects and provides access to international scientific production to educational and research institutions in Brazil. It has a collection of more than 36 thousand titles with full text, 126 reference databases, 11 databases exclusively devoted to patents, books, encyclopaedias and reference works, technical standards, statistics and audio-visual content.

Health Sciences, Physical Sciences and Social Sciences since 1823 to the present. **SciELO** is a database of full texts and free access journals websites. It offers free access to journals, bibliographic databases and full texts available on Internet, particularly in Latin America and the Caribbean, covering various areas of knowledge. It is possible to search by content and to check statistical indicators of use and impact. It offers access to 1,221 journals, more than 500,000 papers and 11,000,000 citations. Although there is a much smaller amount of journals in this database, it was considered relevant for this study as it has great part of the papers published in Portuguese and Spanish. The context of Latin America seemed to be consistent with the interest of the research in the Brazilian eco-innovating behaviour.

Once the databases were selected, it was necessary to define the keywords for the search. Schiederig et al (2012) finds out in their review that the three different notions of green, eco/ecological and environmental innovation are used largely as synonyms while the concept of sustainable innovation is broader and includes a social dimension. For this reason, publications were collected using the following strings: "eco-innovat*", "environment* innovation", "green innovation" and "sustainable innovation". The keywords were introduced with Boolean operator "AND" followed by "Brazil", as we wanted to focus in the Brazilian context. The field was "topic". The data collection took place in November, 2014.

4. Legal and regulatory framework in Brazil

The search for innovation policies and environmental regulations in Brazil seeks to identify a frameworks related to the context of eco-innovation. Besides references in literature, the search was done in the websites of the Ministry of Science Technology and Innovation, Civil House and Ministry of the Environment.

It was clear that environmental policies and innovation policies follow a different path. Environmental regulations are built in terms of penalties. Sustainable aspects are usually related to legislation which forces the firms to change. Concerning innovation, government regulations are more often formulated in terms of incentives than in terms of penalties. They do not make any reference to environmental and socially sustainable aspects. Innovation policies foresee an economic increase and an improvement on the competitiveness.

Innovation policies started to be implemented in the 60s. Regulations of that period proposed incentives which were more related to the development of the academic community. Policies did not focus on technological development of the industry by then. Among other aspects, new laws proposed to reform the graduate level; to establish grants programs to support graduate level and development of research; to establish a regular and consistent system of assessment; to demand qualification requirements from lecturers and researchers of public universities (Pacheco, 2007; Maçaneiro, 2012).

Between 1999 and 2002 about fifteen laws concerning innovation were approved, three of them worth mentioning. Federal Law 8248/1991, known as Informatics Law, provides for the capacity building and competitiveness of the computer and automation

industry. Federal Law 10973/2004, known as Innovation Law, establishes incentives for innovation and for scientific and technological research. It became effective with regulation through Decree 5563/2005. Innovation Law aimed at strengthening the relationship between university and industry through the shared use of science and technology infrastructure by both parts. It also allowed government grants for innovation in firms and encouraged the mobility of researchers outside the university boundaries. Another very important aspect of this law refers to the possibility of transferring public resources to firms as non-refundable funds, which means that government would share the costs and risks of innovative activities (Rocha, 2014).

Brazilian innovation policies establish incentives such as the supply of non-reimbursable and reimbursable funds; equity emission and equity sharing agreements; and tax incentives (Bastos 2012; Rocha 2014). In the early 2000's, Brazilian government funded around R$ 1.5 billion a year for innovation activities (Rocha, 2014). However, Brazil has clearly changed its innovation policy in the last decade, with an increase in public funding and grants as well as in tax incentives related to R&D for the industry. In 2010 innovation funding ranged around R$ 10 billion a year due to important initiatives of the government (Rocha, 2014).

Federal Law 11196/2005, known as Good Law ('Lei do Bem'), provides tax incentives for technological innovation and strengthens the advances of the Innovation Law. Among others, the tax regime and fiscal incentives sets up: deduction expenses on R&D (between 60% to 100%) from income tax and social contributions on net profits; reductions in the tax on industrial products for acquiring equipment and machines for R&D activities (50%); funding to firms for hiring researchers (with Master degrees and PhDs) for the development of technological innovation activities (40% to 60% of the salaries).

In terms of environmental regulations, during the 1970's, environmental protection did not play a leading role in Brazilian scenario. In 1972, for example, Brazil's position towards Stockholm Conference was that environmental protection was a secondary objective, behind economic development. At the same time, most of the population did not have a clear awareness of environmental problems and did not position itself in defence of the environment. Nevertheless, with the growth of environmental problems, the Federal Government created the Special Secretariat for the Environment (SEMA) in 1973 and defined the National Development Plan (PND) for the period 1975-1979, including control standards of industrial pollution and environment preservation.

During the 80s and 90s, there was the beginning of a public awareness regarding environmental issues. The civil society started to discuss environmental issues and pressed federal, state and local governments which started to implement stricter regulations to firms and to strengthen environmental protection. The enactment of Law 6938, 31 August 1981, which deals with the National Environmental Policy, became a crucial boundary to environment protection. From 2000 onwards, there was an increase of environmental legislation in terms of number, scope, specificity and accuracy.

In Brazil, the development of environmental governance is clearly characterized by a disarticulation among several government departments or units; by a lack of central management; and by a lack of financial and human resources (Donaire, 2007). Some historical events have contributed to the development of this situation, as for example, the colonization with deep interest in the exploitation of natural resources which is still reflected in the current exploitation of mineral and agricultural resources for export; the economic growth strategies, in the 1950s, focusing on industrialization, bringing consequent growth of industrial pollution and resources depletion; the process of urbanization and the lack of sanitation; until the very recent water and energy supply problems, which is being considered a serious crisis, especially in the southeast of the country (Motta and Young, 1997; Donaire, 1997). Motta and Young (1997) add that public administration in Brazil has historically been bureaucratic and very sensitive to political interference, with inadequate prioritization. At the same time, economic development has been strongly regulated by command and control instruments, usually applied during a period of an authoritarian political system.

Environmental policy in Brazil has been gradually developed over the years. Moura (2013) identified political nuances in four phases synthesized bellow:

- 1930 until 1960 – The core concern at the time was the rational natural resources control, aiming at improving its economic use. At the end of the 1960th, environmental concerns gained momentum from the society demands, emerged after the growth in environmental pollution derived from industrial activities.

- 1970th – In 1973, the first environmental organization was created, the Special Environment Secretariat (Sema), coordinated by the Ministry of Interior (Minter). Sema agenda focused in controlling the industrial pollution problem and the management of protected areas.

- 1980th – The main landmark in the 1980s was the National Environment Policy, which created the National Environment System (Sisnama). This System set principles, directives, instruments, and assignments for the Brazilian Federation in the national environment area. In 1989, various federal entities were joined up in a single and superior institution, called Brazilian Institute of Environment and Natural Resources (Ibama).

- 1990th – The Environmental Secretariat linked to the Brazilian Presidency administration (Semam/PR), was created in the beginning of the decade, reflecting the increase importance of the environmental topic. This is due to the realization of the UN Environmental and Development Conference, Rio 92, in Brazil. The Conference resulted in the creation of the Brazilian Ministry of Environment.

- 2000 until 2012 – The Brazilian Forest Service was created in 2006, an autonomous body linked to the Ministry Brazilian Environment. In 2007, it was created the Chico Mendes Institute for Biodiversity Conservation (ICMBio), a federal agency also linked to Ministry Brazilian Environment, in charge of managing all federal

conservation units. In 2012 Brazil was the headquarters of Rio + 20 - the United Nations Conference on Sustainable Development (UNCSD). An important event in 2009 was the promulgation of the national policy on climate changes.

5. Search in the databases

The search for the keywords "eco-innovat*", "environment* innovation", "green innovation" and "sustainable innovation" found 1,527 publications in the three databases: Scopus, Web of Science and SciELO. The extracted publication types include journals, conference proceedings and books. However, after introducing the Boolean operator "AND" followed by "Brazil", the number of publications had a drastic fall. Just 53 publications were found meeting the requirements. The extracted publications were analysed using bibliographic information of the authors, publication years and journal names. After reading the abstracts, and when necessary the paper itself, some papers needed to be excluded for the following reasons: (i) Brazil was peripherally cited in the paper; (ii) the publication was repeated in the results (either because of the search of a different term or different database); (iii) the publication did not deal with eco-innovation, but peripherally cited on of the terms of the search. After the exclusions there were just 32 publications left.

The determinants identified in the 32 publications referring to eco-innovations in the Brazilian context pointed to different aspects. The main determinant found in most studies is the conformity to the regulations. But other determinants were found such as: improve the image for society; attend a local community claim; attend the customer's environmental concerns; attend the compliance of an environmental non-governmental organization pressure; conform to environmental requirements made by the financier and to the requirements of environmental certification, in agreement with the adoption of eco-innovations related to competitive advantage achievement or market pressures (Young and Lustosa, 2001; Podcameni, 2007; Kamerer, 2009) or to institutional pressures by external stakeholders (González-Benito and González-Benito, 2005).

In one of the papers examined, for example, Almeida (2010) realized a survey with 92 companies of dairy products. The study shows there was a positive association between the intensity of expenditures with environmental legislation and the variable of economic and environmental performance; economic performance suffers negative influence of legislation regarding compliance with technical standards and time of the environmental license expedition; the intensity of expenditure has positive relationship with improved environmental performance of firms; positive association between green marketing and products sales. Camara and Passos (2005), in a survey with 63 Brazilian chemical companies, analysed the impact of firms' environmental behaviour on their competitive performance. The results point to environmental regulation as a major factor mentioned by all firms and search for good reputation as the second factor most cited. A previous survey from BNDES, CNI and SEBRAE (1998) with 1,451 firms on environmental management in Brazilian industry showed that meeting the regulations is a major reason for the adoption of environmental management practices (56% of firms), considered more important than reducing costs. Other reasons were: improvement of the image in society (21%), attendance to community claims (17%), customer service with

environmental concerns (16%) and the service pressure of environmental non-governmental organization (2%).

6. Discussion

In Brazil, the development of environmental management is clearly characterized by a disarticulation among several government departments or units; by a lack of central management; and by a lack of financial and human resources (Donaire, 2007). Some historical events have contributed to the development of this situation, as for example, the colonization with deep interest in the exploitation of natural resources which is still reflected in the current exploitation of mineral and agricultural resources for export; the economic growth strategies, in the 1950s, focusing on industrialization, bringing consequent growth of industrial pollution; the process of urbanization in big cities and the lack of sanitation; until the very recent water and energy supply problems, which is being considered a serious crisis, especially in the southeast of the country (Motta and Young, 1997; Donaire, 1997). Motta and Young (1997) add that public administration in Brazil has historically been bureaucratic and very sensitive to political interference, with inadequate prioritization. At the same time, economic development has been strongly regulated by command and control instruments, usually applied during a period of an authoritarian political system.

In order to stimulate the introduction of eco-innovations in the Brazilian industry, it is not enough to encourage the development of innovations in general. There must be programs and policies aimed at the integration of environmental issues in the firms' strategy. Eco-innovations development and policies can generate incentives to reduce emissions by firms, as they would seek for alternative technological ways to reduce environmental damage. Moreover, the technology policies may be less costly if used as complementary and not as a substitute for environmental policies. Without these policies, firms have little incentive to switch to a more sustainable technological trajectory. That is, policy interventions that aim to internalize the cost of environmental damage can induce technological change stimulating the creation of environmental technologies by firms.

Innovation policies postulate the improvement of the competitiveness and an economic growth. But, in practice, they do not work as environmental and socially sustainable measures. Sustainability is typically linked to regulations that impose additional strength to cause change. Thus, an important aspect to be included in innovation policies is the promotion of competitiveness, **but avoiding negative environmental effects and considering the limits of natural resources.**

Innovation and environmental policies follow two different patterns. Government regulations concerning innovation are built in terms of incentives. Government regulations concerning the environment are built in terms of penalties: either they are “command and control” type (which does not allow free choice, as the firms have to

obey the rule or will be subject to penalties), or they are “economic” type (when it affects the costs and benefits of the polluter, influencing their decisions to produce an improvement in environmental quality: as, for example, taxes and fees, subventions, tradable pollution licenses.

The empirical studies identified in the search helped to confirm that regulation is an important determinant of the adoption eco-innovations in Brazil. But other determinants are introduced, like attending the environmental requirements made by the financier, which deserves further investigation. The very low number of publications confirms there is a lack of studies on the adoption of eco-innovations by Brazilian firms. It points to the need of developing primary research on this area considering aspects such as the barriers for adoption, the diffusion process and the impacts caused on environmental policy.

7. Conclusions

Although ecological issues became part of the innovation agenda and eco-innovation is already a crucial field, Brazil lacks specific literature on the area and needs to advance a local discussion. With a tradition of having a very bureaucratic public administration which is sensitive to political interference, the innovation policies did not deal with environmental issues until very recently. Environmental and innovation policies should be aligned, complementing each other.

Environmental regulation can be a major determinant of eco-innovations in highly polluting sectors, as it may induce companies to introduce products and processes which are less damaging to the environment. On the other hand, in other sectors, the main factors that induce the development of the eco-innovations can be related to the search for productive efficiency and increased competitiveness.

Innovation policies and environmental policies should be complementary, as the regulatory framework is a determining factor for eco-innovative behaviour in companies. Policies which encourage the development of innovations are of indisputable importance. Much of the environmental regulation and innovation policies influence eco-innovation strategies within the firms. So, government can stimulate eco-innovation adoptions by the firms through laws that include grants, loans, financing and other incentive tools.

On the other hand, the more environmental issues are formalized in the internal context of the firms, the more the environmental preservation issues will be part of the organizational culture.

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